

**THE DIAGNOSIS OF TUMORS OF THE CAUDA EQUINA, CONUS AND EPICONUS MEDULLARIS: A REPORT OF NINE CASES.**

BY HARRY L. PARKER, M.B. (UNIV. DUBLIN),

SECTION ON NEUROLOGY, MAYO CLINIC, ROCHESTER, MINNESOTA.

TUMORS of the cauda equina and conus medullaris are not rare, and there has been no dearth of literature on the subject. Spiller, in 1908, reviewed all the literature up to that year and described eight cases that he had seen. Since then many other excellent articles have been published and new cases added to the number already recorded. It is therefore with some hesitancy that I venture to add to this long list my own observations on a few cases examined at the Mayo Clinic with a short account of each. Only cases in which the presence and location of a tumor had been definitely established by operation are recorded here, together with another case which is of interest from the point of view of diagnosis.

I have found eight cases of this disease in the records of the Mayo Clinic, since 1916, and five of these I had the privilege of observing during my service in the Section on Neurology.

The eight cases were selected from thirty-three cases of spinal cord tumors that were observed from January 1, 1916, to January 1, 1921—a somewhat high rate of incidence when it is considered that Steinke, in 1918, found only thirty cases of tumors of the cauda equina and lowest segments of the spinal cord in an analysis of 330 cord tumors.

**REPORT OF CASES.**

**CASE 1 (248240).** Mrs. C. L. B., aged twenty-nine years, came to the Clinic October 11, 1918. She complained of pain in the back and a limp in the right leg. Since the birth of her baby, two years before, she had had pain around the first and second lumbar vertebra, which had gradually grown worse in spite of various treatments. In July, 1918, she noticed that her right foot was becoming weaker and that it was difficult to stand on the ball of that foot. This also had become progressively worse, so that she had to raise her foot to clear the ground. The function of her bladder was normal and she was not conscious of any loss of sensation. The pain radiated down the back of the right leg, and in getting out of bed in the morning she had a tingling in the soles of her feet. She felt better sitting and had to leave her bed for four hours at a time to sit in a chair.

Examination revealed almost complete loss of power in the calf of the right leg and the peroneal and anterior tibial muscles of the right foot. There was a hypotonus of these muscles and fibrillary twitchings were seen in the peroneal and anterior tibial muscles.

Both patellar reflexes were exaggerated, but no definite Babinski sign was seen. The Achilles reflex on the right was absent; on the left it was diminished. Both external hamstring tendon reflexes were absent. The patient's gait was steppage in type and there was a very slight diminution of sensation to pain and temperature over the posterior surface of the right thigh (Fig. 1). Touch sensation was normal. Pressure on the eleventh and twelfth dorsal spines, which were prominent caused definite severe pains to radiate down

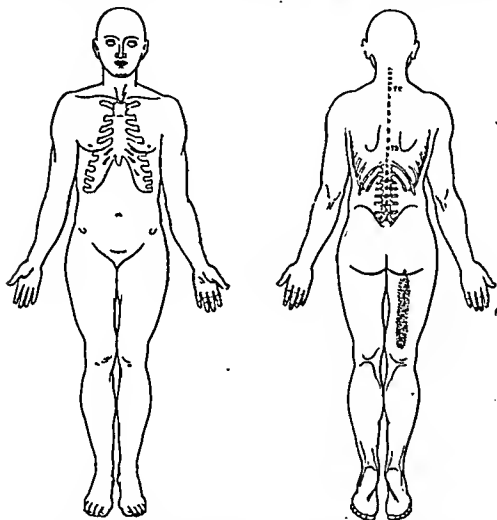


FIG. 1.—Case 1 (248240). No incontinence of urine or feces. Intradural extra-medullary, encapsulated glioma. (Complete , partial , slight  loss of sensation of touch, temperature, and pain).

the posterior aspect of each thigh. Pressure on the sacrum did not cause pain. Roentgenograms of the lumbar spine revealed nothing abnormal, but the spinal puncture produced a yellow fluid which became almost solidified when the Nonne test was performed. A small spontaneous clot and a heavy coagulation formed with boiling. A diagnosis of an intradural extramedullary tumor of the cauda equina was made. A laminectomy was performed October 30, 1918 (Dr. Adson), and a reddish-gray encapsulated intradural extra-medullary tumor was seen extending from the eleventh dorsal verte-

bra to the upper border of the fourth lumbar vertebra. The tumor, a glioma, was 15 cm. long and 1.5 cm. in diameter.

CASE 2 (279754). A. B., a boy, aged sixteen years, came to the Clinic, August 14, 1919. He complained of pain in the right lumbar region. Twelve months before he had noticed an intermittent dull pain in the right lower quadrant of the abdomen and right lumbar region. This lasted from two to three days and was then absent

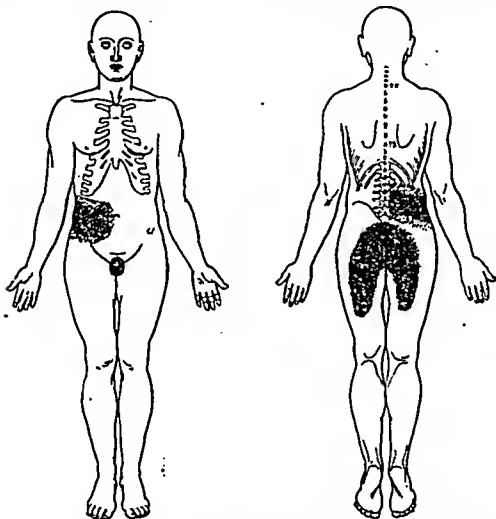


FIG. 2.—Case 2 (279754). Incontinence of urine and feces. Extradural secondary carcinoma. (Hyperesthesia to touch, temperature and pain [shaded]).

for one week. At times the pain passed over both hips, sacrum, and down the back of both legs. He described it as a "numb" pain, with a feeling of pin and needle pricks in the skin covering the right lower quadrant of the abdomen. Six months before he had had his appendix removed for this pain, without relief. He had difficulty in holding urine at times, but no trouble in starting.

The patient returned to the Clinic December 22, 1919. The pains were worse and still in the right lower quadrant of the abdomen, the back, and the posterior aspect of the thighs. He felt a girdling

sensation over the lower thorax. About twelve months from the onset of pain he began to lose power in his legs and was forced to use crutches. Six weeks before his second visit to the Clinic he became unable to walk at all. Fourteen months from the onset he had to use a catheter to empty his bladder and had no control over bowel movements. He had pain in the legs when he coughed or even swallowed.

Examination of the patient showed an atrophic atonic paresis of both lower extremities equally distributed in all muscles below the glutei and the psoas. He had an anesthesia over the area supplied by all spinal cord segments below the first sacral, and a large patch of greatly diminished sensibility on the right side occupying the right lower quadrant of the abdomen in front and the area of skin included between the second lumbar spine and the fifth lumbar spine behind (Fig. 2). The margins of this area were hyperesthetic, especially over the eleventh dorsal to the first lumbar spinous process. He could neither stand nor walk and he was incontinent of both urine and feces. Patellar, Achilles, and plantar reflexes were absent and the feet were very much swollen. The spinal puncture disclosed a milky, cloudy fluid containing seven small lymphocytes for each cubic millimeter; it clotted readily. The Wassermann reaction was negative, but the Nonne test was positive. A diagnosis of cauda equina tumor was made.

The patient was operated on, December 30, 1919, by Dr. Adson who found an unencapsulated cellular mass, extradurally situated opposite the eleventh and twelfth dorsal and first, second, and third lumbar vertebrae, with a small projection running laterally and anteriorly to the cord as high as the ninth dorsal vertebra, also extradural. The tumor involved both the bone and dura extensively and was reported to be a secondary carcinoma, although no primary source was discovered.

CASE 3 (294401). Mr. F. E. M., a thin poorly nourished man, aged forty-two years, came to the Clinic October 24, 1919, complaining of pain and weakness in both legs. Five months before there had been a gradual onset of pain and numbness in the left lower extremity along the posterior aspect of the left buttock, thigh, and leg. This pain had persisted and increased in severity. Two months before pain and numbness began in the right leg. Weakness in the legs and difficulty in walking appeared about two months before, and he had noticed that the muscles of the thighs and calves had become smaller. He had to use crutches and felt that he was getting rapidly worse. The stream of urine was often interrupted and had but little force. He had a sensation of swelling in the rectum and recently had become constipated.

At examination the left lower extremity was weak, but not actually paralyzed. The power of the right leg was only slightly diminished.

The muscles were atonic and atrophie, but no fibrillary twitchings were seen. Both tendo Achillis reflexes were absent and the patellar reflexes were almost absent. Sensation was not greatly disturbed, although there was some loss of sensation to pain and touch along the posterior aspect of the thigh, buttock, and leg in the area supplied by the fifth lumbar to the fifth sacral segments of the spinal cord of the left side. Control of the bladder and rectum was greatly diminished and a Kernig's sign was present on the left side. The left sciatic nerve was tender. A spinal puncture was performed October 18, 1919, and while the Wassermann and Nonne reactions were negative, there were a great number of pus cells in the fluid. A tentative diagnosis of localized subdural abscess was made and laminectomy was advised.

Operation was performed, October 30, 1919 (Dr. Adson). After the laminectomy an extradural malignant glioma was seen in the spinal canal; it extended from the third lumbar vertebra to the end of the sacral canal. Some of it extended anteriorly and on several of the caudal roots, forming separate tumors as they left the dura. An inflammatory band was stretched across the dura compressing it so that a small cyst was formed. This contained cloudy spinal fluid and communicated with the subdural space.

CASE 4 (310356). Mr. O. G., a poorly nourished man, aged thirty-two years, was brought in a wheel chair to the Clinic, March 27, 1920. He complained of pain in his back and of not being able to walk. Eight years before, while wrestling, he hurt his back and at different intervals since then he had had pain in the middle lumbar region. In March, 1919, he had noticed difficulty in starting urine, and about August he felt tingling in the soles of his feet and his lower limbs began to become weak and difficult to control. He used a cane from August to January, when he was forced to use crutches, and even this was difficult. In September, 1919, the pain became very much worse and spread to the legs, abdomen, and hips. He described it as a "pulling, sharp" pain growing steadily worse. In January, 1920, he found he had to use a catheter to empty the bladder. He was constipated, but feces did not leak when they were liquid. He had frequent erections, four or five each day, but he could not ejaculate. The pain and numbness extending from the epigastrium to the legs was especially bad when he was lying down, and he had to sit up to sleep for the past two or three years, using three or four pillows under his back.

Examination showed an almost complete atrophic loss of power from glutei downward with fibrillary twitchings on the left side. Patellar and Achilles reflexes were absent and there was no Babinski sign. The abdominal, hypogastric, and cremasteric reflexes were absent, but the epigastric reflex was present. He could neither stand nor walk and his lumbar spine was held rigid. There was no

particular tenderness except from a recent spinal puncture. His feet and legs were anesthetic to pain, touch, and temperature, and his thighs were partially so. The level between disturbed sensation and normal skin was not clear-cut, but was within the area supplied by the third lumbar segment, so that sensation was normal above that segment, but descended from only partial loss at that segment to complete loss around the second, third, fourth, and fifth sacral segments. Spinal puncture was attempted but resulted in a "dry tap." The roentgenograms revealed nothing of note in the bones and the sacrum. The Wassermann reaction was negative. A diagnosis of a cord tumor involving the cauda equina was made.

At operation, April 7, 1920, (Dr. Adson) a large, elongated, soft, well encapsulated, intradural, endothelioma was found, extending from the tenth dorsal vertebra to the fifth lumbar vertebra; thus it was about 20 cm. long, situated on the dorsal aspect of the cauda equina and extending above the conus terminalis.

CASE 5 (315328). Mr. W. H. P., a pale, undernourished man, aged fifty-two years, walking with the help of a cane, came to the Clinic May 10, 1920, stating that he had locomotor ataxia. He complained of pains and numbness in his legs and difficulty in walking.

Three years before he had experienced a painful, burning numbness in the left foot which lasted about one hour. Four or six weeks later the same feeling returned in the same place and for the same period of time. Gradually these sensations became more frequent and lasted longer. Two years before, the same sensation commenced in the right foot and leg and for one year both were about equal, but for the last year the pain had been more severe in the right leg. A year before his sexual power began to fail, and when he came to the Clinic was almost absent, but the functions of the bladder and rectum remained normal. About twelve months before he began to lose power in his lower extremities and had to use a cane; this grew progressively worse. In the left leg the pain was more of a burning numbness, but in the right leg it was cramp-like and, as he described it, it "grips me like a bull-dog." He had difficulty in controlling his gait and was afraid to venture out after dark. His pain was relieved by walking and movement and was made worse by lying down.

Examination revealed that the patient had a weakness in his lower limbs, most severe in the hamstring, peronei, anterior tibial, and toe muscles, or the muscles supplied from the fourth lumbar to the first sacral segment in the spinal cord. The muscles supplied by the second sacral or third lumbar segments were much less affected. Sensation to touch, temperature, and pain was equally and severely disturbed over an area supplied by the fourth lumbar, fifth lumbar, and second sacral segments of the cord (Fig. 3). The sensation of skin areas corresponding to one segment below and one above

these segments were markedly less interfered with. The line of demarcation between normal and abnormal sensation was not clear-cut and the sensory disturbance around the anus was almost negligible. The anterior surface of the thigh was normal. Both motor and sensory disturbance corresponded to the segmental area supplied by the fourth and fifth lumbar, first sacral and part of the second sacral segments. Pressure sensibility was normal, but both vibration and joint sensibility in both lower limbs were severely dimin-

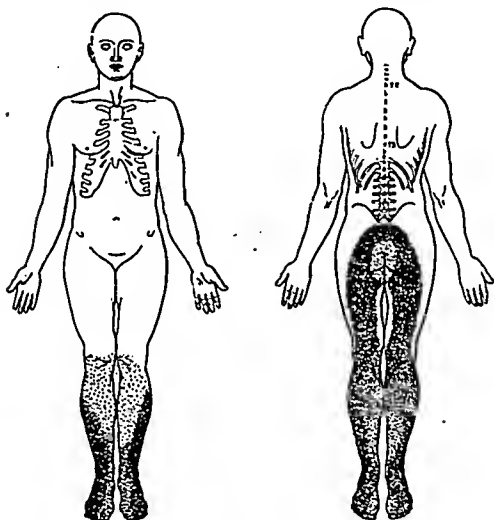


FIG. 3.—Case 5 (315328). No incontinence of urine or feces. Intramedullary epiconus tumor.

ished. The patient's gait was very ataxic. There was no dissociation of sensation. The patellar reflexes were diminished and the Achilles and cremasteric reflexes were absent. There was no Babinski sign. The weakened muscles were both atrophic and atonic and showed abundant fibrillary twitchings. Distinct pain was felt on squeezing the Achilles tendon, adne xcept for the segmental areas mentioned, there were no disturbances of sensation anywhere on the body. The spinal fluid examination showed a positive Nonne

reaction, a negative Wassermann reaction and five lymphocytes. A diagnosis of cauda equina tumor was made.

Operation was performed, June 1, 1920 (Dr. Adson) and an intramedullary tumor bulging the lower portion of the cord above the cauda equina was found. The cord substance was infiltrated and a second operation was deemed advisable. Unfortunately the patient died before this could be done.

CASE 6 (315631). Mrs. R. J. F., a thin emaciated woman, aged twenty-eight years, was brought to the Clinic in a wheel chair, May 12, 1920. She complained of being unable to walk and of having pain in her legs. She had had an appendectomy and bilateral partial oöphorectomy performed for her trouble without relief. Two and one-half years before she noticed a sore, burning spot localized to the right great trochanter. This lasted three months and then finally disappeared. Two years before she had sudden severe pain in the hips and the lower lumbar region, worse at night, and about the same time she noticed slight weakness in the lower limbs. This attack of pain lasted about two months. Twelve months before she had to have assistance to walk, and for the last two months had not been able to walk at all. The left leg was worse than the right. As weakness increased, pain diminished in severity until little or none remained. She had not had incontinence of urine, but the flow was hard to start at times. She complained of being constipated and of the stools escaping when liquid. The pain occurred at night, causing her to sleep sitting up. Walking seemed to relieve the pain, which was most intense over the right great trochanter. It never had radiated down the back of the thighs.

At the time of examination the patient was unable to walk, owing to an atonic atrophic paralysis of the peronei, anterior tibial, and the toe muscles. Her calves, thighs, rotators, and adductor muscles were less affected, also the psoas and quadriceps. Weakness in each leg was about equal and the muscles supplied by the spinal segments below the fourth lumbar were most affected. Those supplied by the second and third lumbar were less so. She had an almost complete loss of sensation to touch, temperature and pain over the skin areas supplied by the fourth and fifth lumbar and the first sacral segments, and a small amount of sensation remaining over the left instep. The skin areas of the second, third, fourth, and fifth sacral segments, though hypæsthetic, seemed to be much less affected. There was a patch of hyperæsthesia over the right posterior inferior iliac spine. Patellar, Achilles, and plantar reflexes were absent, and over the legs there was a loss of pressure sensation. Both joint and vibratory sensibility were seriously damaged. There was a permanent shortening of both hamstring groups of muscles, due apparently to the patient having remained sitting up night and day for a long time. The greatest damage was shown in areas



supplied by the fourth and fifth lumbar and first and second sacral segments of the spinal cord. A spinal puncture resulted in a "dry tap." A diagnosis of tumor of the cauda equina was made.

Laminectomy was performed, May 25, 1920 (Dr. Adson). An ependymal cell glioma, 3 cm. in diameter, extending from the eleventh dorsal vertebra above to the fifth lumbar vertebra below, was found. It had infiltrated both the cord and the roots of the cauda equina and extended into the sacral canal.

CASE 7 (341502). Mrs. J. S. G., aged twenty-five years, came to the Clinic, November 20, 1920, complaining of pain in her right hip. Two and one-half years before she had felt the pain over the tuberosity of the ischium on the right side and over the outer surface of the right leg. The pain came on during her third confinement and lasted until the birth of a healthy child. It reappeared three weeks afterward and lasted for four months. She had no symptoms during the winter of 1918, but in February, 1919, pain commenced again in the same two places and was more severe, lasting this time about four months. During the winter of 1919 and 1920 she was free from pain, but in March, 1920, it started again and persisted. In July her feet became swollen and she found that her back was stiff and a sudden jar to the spinal column caused the pain to radiate along both sciatic nerves. Gradually increasing pain in the lumbar spine was noted. In October, 1920, she discovered that she was not voiding urine for considerable periods, and then a large quantity would pass involuntarily. The urine had a strong odor. Feces escaped when liquid, and gas was not retained. She had not noticed loss of sensation, and she was sure that her limbs had complete power and that she could walk and run as well as ever. She described her pain as dull, burning, and constant, felt in the lumbar spine, tuberosity of the ischium and outer side of the right leg. It kept her awake at night and she found some relief in sleeping sitting up. In all her spells of pain she had slept sitting in a chair, and at times had had greatest relief by sleeping with her knees on a chair and her trunk on a table face down.

Examination revealed a well-developed woman, with loss of muscular power, and walking without even a limp. There was a loss of sensation to pain, touch, and temperature over the area supplied by the second, third, fourth, and fifth sacral segments on the right side and the fourth and fifth segments on the left side. There was also a partial loss of sensation over the fifth lumbar and first sacral segment on the right side (Fig. 4). Patellar and Achilles reflexes were absent, and there was no Babinski sign on either foot. Kernig's sign was present on the right side and there was marked limitation of movement of the lower part of the spine. She had pain in the lumbar spine when lying on her back and local tenderness over all the lumbar spines. Pressure over the third, fourth, and fifth lumbar

spines produced pain radiating down the sciatic nerves. The sphincter control of the bladder and the rectum was partially lost and both anal and hypogastric reflexes were absent. The roentgen examination of the lumbar and sacral vertebrae showed nothing of note. The spinal fluid Wassermann reaction was negative. The Nonne test was positive. A diagnosis of cauda equina tumor was made. An exploration was made of the cauda equina November 30, 1920. (Dr. Adson.) A large ependymal cell glioma was found, the

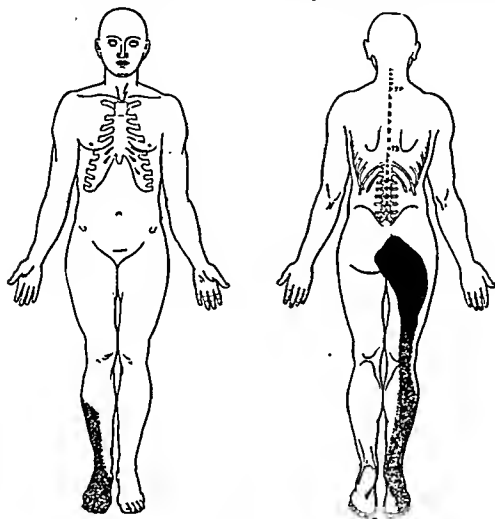


FIG. 4.—Case 7 (341502). Incontinence of urino and feces. Ependymal cell glioma involving the cauda equina.

upper level of which was as high as the second lumbar vertebra, while its lower part has invaded the dura, bone, and even the lumbar muscles at the lumbosacral juncture, and it filled the sacral canal below. Its upper portion was intradural and extramedullary, but the lower portion had infiltrated the lumbar muscles to within half an inch of the skin.

CASE 8 (341775). Mr. A. C. H., a poorly nourished man, aged twenty-seven years, came to the Clinic, November, 1920, complaining

of pain in the lower part of his back and the back of his legs. Five years before he had had an attack of severe pain along the course of both sciatic nerves. This lasted two weeks. Another similar attack came on four years before, lasting one week. About this time he noticed that a blow in the back caused pain to shoot down his legs. About two and one-half years before his back became stiff and motion or jarring of his spine produced severe pain. He was then in France driving an autotruck, which jarred him so much that

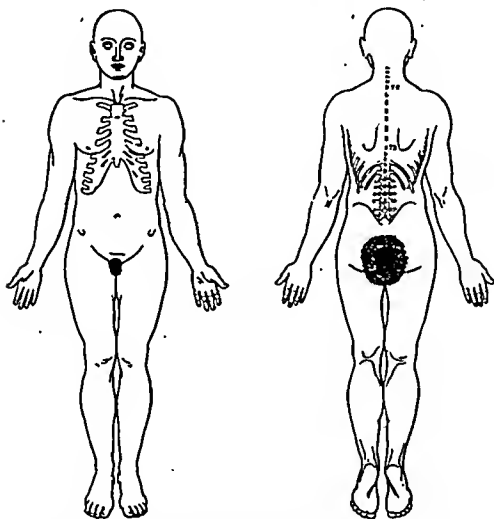


FIG. 5.—Case 8 (341775). Incontinence of urine and feces. Ependymal cell glioma involving the cauda equina.

he had to cease work and was invalided home. On the journey home he had painful spasms of the hamstrings and calf muscles, so that his legs were doubled under him at times. Two years before he found that he had difficulty in expelling urine, and this trouble became gradually worse, so that in the last six months he had to use a catheter. He had difficulty in retaining liquid feces and gas. The pain was a dull ache, like toothache, felt most in the lower lumbar spine and posterior aspect of each thigh. It hurt him to sit on a

hard chair. He felt better in the morning. Movement and walking brought on the pain and he felt better if he remained quiet.

At examination a well-marked weakness of the lower limbs, although not of great degree, and a rigid painful lumbar spine were found. The patient walked slowly and painfully but with a definite limp. The muscles were atonic and atrophic, but there were no fibrillary twitchings. The patellar and tendo Achillis reflexes were almost absent. The anal and bulbocavernosus reflexes were absent and the cremasteric reflex was almost absent. There was a well-marked anesthesia over the skin supplied by the fifth sacral segment on each side, and the third and fourth sacral segments seemed also a little disturbed, so that, on the whole, sensory changes were slight (Fig. 5). Over the fourth lumbar spine there was a spot of exquisite tenderness; pressure there produced pain that radiated down both legs. Sensation of vibration was diminished in both lower extremities. Both sciatic nerves were tender and Lasegue's sign was present. Roentgenograms revealed a round symmetrically placed area of diminished density at the level of the first and second sacral vertebrae. It was impossible to estimate its significance previous to operation. Spinal puncture, although repeated once or twice, was not productive of fluid. A diagnosis of cauda equina tumor was made.

Operation was performed, December 7, 1920 (Dr. Adson), and an ependymal cell glioma was found, extending from the eleventh dorsal vertebra to the second sacral vertebra, with obvious further extension upward. It was also found that the laminae of the first, second and third sacral vertebrae were missing, constituting a spina bifida. In this space was some yellow fluid and the tumor extended into it.

#### GENERAL CONSIDERATIONS.

In studying the course, symptoms, and signs of this disease, there is always before us the desire to discover some common factors which might make its recognition easier in the future. If this disease followed a course of mathematical exactitude all would be well, but also there would be no need of a diagnostician. In the vagaries and eccentricities of the disease we have ample scope for training ourselves in the diagnosis and localization of spinal cord tumors. Tumors in this portion of the vertebral canal present a completely different picture from that shown by tumors higher up, and, further, tumors at widely separated levels may give almost identical signs and symptoms.

The combination of sphincter disturbance, atrophic paresis of the lower limbs and perineal anesthesia is characteristic of the disease, but the determination of the position and extent of the tumor mass is in some cases an impossibility. Reference to Case 9 will demonstrate this fact.

All of these cases are different and each is worth a close study. To draw any but general conclusions from them when studied in the aggregate would be to invite error, and perhaps the most obvious fact observed is that the more closely they are studied the more they seem to differ.

**PATHOLOGY.** The strongest factor in the production of differences in course, symptomatology, and physical signs is the nature of the tumor in each case. The more malignant the type of tumor the more rapid will be the course and the more diffuse the signs, while a slowly growing tumor will have a long course and clear-cut signs. It is well to contrast the picture shown in Case 3 with that shown in Case 4. In the former there is a short history and a diffuse distribution of signs and symptoms; in the latter the history is long and the signs are clear-cut, distinct, and symmetrical. The cases of giant endotheliomas of the cauda equina described by Collins and Elsberg had a relatively long course, but the tumors were not encapsulated and spread in all directions, filling the sacral canal. Here also the signs were few, patchy, irregular and affected different roots and segmental areas with varying degrees of intensity. Since a relatively malignant tumor may spread in any direction from its origin and may spread upward or downward, intradural or extradural, an arbitrary classification of such tumors on the basis of their position is completely useless, for a tumor that one would expect to find clearly intradural and confined to a small area on operation might be found to have a wide and destructive situation.

The sacral canal, as compared to the other portions of the vertebral canal, is relatively wide and a tumor may grow for a long period without giving any localizing signs. A tumor in the dorsal canal as soon as it infringes on the posterior nerve roots or any part of the cord will give a sharply marked level (unless it be intramedullary), but a tumor in the sacral canal, where the first sacral root is as long as 14 cm., does not announce its position with such a degree of exactitude.

Of the eight tumors only two were encapsulated, and one was diagnosed by the pathologist as an endothelioma and the other a glioma. The remaining six cases, with the exception of Case 5, were tumors which showed a tendency to erode the dura, bone, and muscle approaching even to one inch of the skin (Case 7). Case 5 was obviously a relatively benign tumor, but no pathological diagnosis was made.

Cases 6, 7, and 8 were ependymal cell gliomas and the course of the disease, as well as the findings at operation, were somewhat similar. In these patients the tumor filled the sacral canal and extended up into the lumbar region higher than the surgeon thought it safe to invade. These tumors have a long insidious course and produce a great amount of destruction of everything they encounter with surprisingly few signs. Case 7 is a good example of the course

and signs of such tumors. Clinically in their degree of malignancy, such tumors come midway between so-called malignant gliomas and encapsulated gliomas. They are destructive in their progress but are relatively slow growing. The more salient features of the symptomatology of these eight cases were as follows:

**PAIN.** The earliest and most constant symptom in this disease is pain. It is also the most distressing feature. It may appear many months, even years (Cases 4 and 8), before any sign of the disease is established, and, whereas at first it is light and intermittent, with long intervals of freedom, later it becomes constant day and night and leads the patient to adopt any means to obtain relief. In a few of the patients a solitary attack of pain appeared months before it was repeated; why there should be so long an interval is difficult to explain.

The patients soon discovered that movement relieved them of their agony, and, while jarring and sudden movements initiated a spasm of suffering, on the whole their pain was less severe while they were walking. Five of the 8 patients had slept sitting up in a chair for months, and when they were no longer able to walk, remained day and night in the chairs in which they were wheeled. One patient (Case 6) had a permanent contraction of her hamstrings from such a position. In five patients there was an intolerance to the prone position in bed. One patient (Case 8) spent nights kneeling on a chair and lying face downward across the table. This attitude was noted also by Schinoll in a case he recorded. The pain was either diffuse and radiated from the back down the posterior aspect of the thighs, so that the patient moved his hand over a large area in pointing to the site of his pain or he pointed to one isolated area as being the site. This was noted in Cases 5, 6 and 7.

The tumor in Case 5 was intramedullary and in Case 6 it was probably so placed at the commencement of the disease. Both of these patients pointed to one spot as being the constant position of the pain; there was no radiation along the sciatic nerves.

Pain in the lumbar spine was not confined to cases in which the vertebrae were actually eroded. It seems to have been felt even in Case 5 in which the tumor was definitely intramedullary. The pain was also severe in this case, but certainly not so severe nor so well marked as in the cases in which the vertebrae were actually eroded and the spinal column was rigid. Such lumbar pain is valuable at times for localization, as may be noted in Case 1, in which the pain and tenderness were over the exact site of the tumor. Some pain was felt as a result of root irritation, but it was felt some distance away. That is, the pain in the back was over the first and second lumbar vertebrae, but the root pain was over the posterior aspect of the right thigh. Pain in the back, therefore, is not confined to cases of tumors eroding the vertebrae; it is common in caudal tumors and even in purely intramedullary conus tumors.

To find where the pain was first felt is valuable as an idea of the starting-point of the tumor, and by comparing it with the widest limit of the pain in the later stages of the disease a good idea of the spread of the tumor may be gained.

The nature of the pain is important as a point of differential diagnosis from such diseases as *tabes dorsalis* and multiple neuritis. The patient in Case 5 described his pain as cramp-like or a burning numbness. Quite different from the flash-like pain of *tabes* from which he was supposed to be suffering. In two cases the pain was suggestive of motor irritation as well as sensory, as there were painful cramps of the muscles (Cases 5 and 8). Many of the patients described their pain as a steady, constant, burning ache.

**TENDERNESS OF THE SPINE.** Tenderness of the back was present in Cases 1, 7, and 8, and was of extreme diagnostic and localizing value in Case 1. In this case pressure on the eleventh and twelfth dorsal spines produced severe pain, radiating down the posterior aspect of the thigh; pressure on the sacrum produced no such result. This was almost certain information that the tumor lay under this tender area. Tenderness was also well marked in Cases 7 and 8, but it is well to note that while in Case 1 there was a benign encapsulated tumor the other two tumors had eroded bone and muscle in all directions. Tenderness, while suggestive of vertebral involvement, is not conclusive. In Case 4 tenderness was absent though sought for. A careful palpation of the lumbar spine should never be neglected in cases of suspected tumors. Rigidity of the lumbar spine was associated with marked tenderness in Cases 7 and 8.

**MUSCULAR WEAKNESS.** Seven of the eight patients were weak in their lower extremities; it was the most prominent symptom in Case 1. The degree of weakness varied; it was slight in Case 3, and there was complete loss of power to stand or walk in Cases 4 and 6. In spite of a long history of severe pain and definite sphincteric and sensory disturbances weakness was absent in Case 7. It was not the earliest symptom nor was it an isolated finding in any of the cases. It was associated with sensory and sphincteric disturbances in all the cases. Paresis of the lower limbs without other physical signs, and even with some pain, does not establish the diagnosis of tumor in this region. For this reason it was difficult to make a diagnosis in Case 1, in which there was only a mild sensory change, without sphincter disturbances. Other factors such as the condition of the spinal fluid, and pressure tenderness helped in making the diagnosis. The muscular weakness was neatly selective in Case 5, in which an intramedullary tumor was confined to a few segments in the *epiconus*; in the other cases the weakness was diffuse and useless for localization. In only one case (Case 1) was weakness unilateral; in Case 3 it was asymmetric. In the remaining 5 cases in which weakness was present it was equally distributed over the

two extremities, especially in Cases 2, 4 and 6, in which the weakness was severe and the disease well advanced.

**SPHINCTERIC DISTURBANCES.** Five of the eight patients had difficulty in controlling the bladder. Next to pain it was the earliest symptom in three. It was not an isolated phenomenon, as in each case it was associated with a perianal or saddle hyperesthesia or anesthesia. In three instances catheterization was necessary to empty the bladder. Rectal control seemed to have been affected in proportion. In one case (Case 5) there was loss of sexual power without loss of control of the bladder or rectum. In Case 4 the ejaculatory part of the sexual act was abolished; the power of erection was maintained. This corresponds to the case of pelvic tumor recorded by Müller and discussed by Spiller, who regarded this phenomenon as being an indication that the fibers for erection leave the cord at a higher level than those supplying the bladder, rectum, and ejaculatory muscles. In Raymond's table the center for ejaculation is said to be in the third sacral segment and that for erection to be in the second sacral segment. These two points are close in the conus. Sanders found a patient who also had genital anesthesia and incontinence of urine with preservation of the function of erection. He interpreted this as being proof that the tumor could not be in the conus on account of one of two centers so close together having been spared. In Case 4, while the tumor did not infiltrate the conus it certainly pressed on it, and I believe with Spiller that it is more satisfactory to explain this phenomenon by regarding the erection center as being at a somewhat higher level than the ejaculatory center and the fibers supplying it to leave at this higher level. Further, it is possible that the center is in the sympathetic ganglia outside the cord altogether. This would explain its escape in lesions of the conus and its freedom from impairment of function. A case such as Sanders recorded does not, in my opinion indicate that the conus was undamaged. Three patients either did not have paralysis of the bladder or it was but little disturbed. In these cases (1, 5 and 6) there was a diversity of pathology. The first patient had a well-encapsulated tumor, the second an intramedullary epiconus tumor above the third, fourth, and fifth sacral segments, and in the third patient the conus and cauda were extensively involved by a malignant tumor, and why he should have been free from severe bladder and rectal incontinence is a mystery. At the same time the sensory disturbance in the third, fourth, and fifth sacral segments was not well marked, indicating possibly a relatively slight degree of involvement of the segments and their roots. Frazier reports a similar case, but without the degree of involvement that was shown at operation or even before operation in this case (Case 6).

These three patients were ill two years, two and one-half years and three years respectively, and yet no bladder disturbance was manifest in that time. Spiller reported two cases, one of two years'



and the other of seventeen months' duration, before death or operation. Neither of these patients had sphincteric disturbance.

Lack of control of the bladder and rectum is therefore not always present in cases of caudal and conus tumors even though the other changes, not excluding even sensory changes, may be severe. The three patients in this series might possibly have developed incontinence had they been allowed to continue, yet they had ample time to develop it prior to operation.

**SENSORY CHANGES.** All the patients had some degree of sensory loss, but the degree varied from a slight loss of sensation, of which the patient was ignorant (Case 7), to complete anesthesia of the lower extremities (Case 4).

The history of sensory change has less value than the other subjective complaints. In three cases any hypesthesia was denied and a patient's statement that there is no sensory change should not be relied on. Some complained of numbness, a cold sensation, and tingling. In three cases only was there any symmetry of distribution of the anesthesia. In one of these the anesthesia was in the fifth segmental skin area, in the other two over the buttocks and back of the lower extremities with involvement of the anterior surface of the leg, but not the thigh. The anesthesia in Case 5 gave more than a hint of the localization of the tumor in the epiconus (fourth and fifth lumbar and first and second sacral segments).

The patch of anesthesia found in the right lower quadrant of the abdomen in Case 2 was shown at operation to have a definite pathologic basis in the branch of the tumor growing up the spinal canal. The slight degree of severity of the sensory changes in the third, fourth, and fifth segmental skin areas in Case 6 was shown to correspond with the position of the tumor at operation and with the freedom of that patient from incontinence. In only one patient was there any suggestion of dissociation of sensation, but the degree of sensory change was so small that no stress could be laid on this. Joint, pressure, and vibratory sensations were impaired in proportion to touch, temperature, and pain; pressure sensibility less noticeably than the other two. This helped us to differentiate a case of epiconus tumor which had been diagnosed *tabes dorsalis*. The patient's joint sensibility was so severely impaired that he was ataxic, but pressure sensibility was almost normal.

The degree of sensory loss of these patients was fairly in proportion to their motor weakness, but was not in proportion to the size of the tumor and the degree of involvement of surrounding structures (Cases 7 and 8). It was impossible to estimate the time of onset of sensory change in any of these cases, since the histories of none of them had been followed over a long period of time.

Fibrillary twitchings, usually indicative of anterior horn-cell involvement, were present in three cases. Two of these cases were extramedullary tumors showing that pressure on the cord will produce this sign without its infiltration.

**TENDINOUS REFLEXES.** As would be expected, the tendo Achillis reflex was absent or diminished in all the cases and the patellar reflexes were intact in only one. The cutaneous reflexes were interfered with in a few cases and helped greatly to estimate the highest level in the cord or the greatest number of roots involved by the tumor.

**SPINAL PUNCTURE.** This procedure must always be adopted to exclude the possibility of an inflammatory or syphilitic condition of the cauda. A "dry tap" is so rarely obtained that it is quite enough to suggest that something in the dural canal, probably a tumor, prevents the withdrawal of fluid. This was illustrated in Cases 4, 6, and 8, in which the canals were choked by large tumors. If the spinal puncture is performed by experts without securing fluid, suspicion of a tumor should be aroused. In Case 1 the xanthochromic and massive coagulation phenomena of Froin were present. This was enough to suggest a tumor above the site of the puncture, where it was found at operation. In Cases 5 and 7 the Nonne test was positive. The spinal fluid findings in Case 2 were equivocal, but in Case 1 they were frankly misleading. A large number of pus cells in the fluid led to a diagnosis of subdural abscess. The roentgen-ray examination of the lumbar spine and sacrum furnished little information beyond a lesion in the spine of Case 8, which afterward proved to be a spina bifida occulta.

**TROPHIC AND VASOMOTOR CHANGES.** In two cases there was evidence of edema of the lower limbs. This condition was discussed by Bailey, who quoted a case of Schmoll's in which the edema was so great that a laparotomy was performed to see if the inferior vena cava was obstructed. It was found that a caudal tumor was solely responsible for the edema.

**DIFFERENTIAL DIAGNOSIS.** Most of the patients presenting themselves for examination had definite physical signs of the disease and the diagnosis of some definite damage to the neural structures was comparatively easy. The differential diagnosis of causes of damage other than by tumor was not so easy. There were few patients, however, who had short histories; the majority of them had suffered intense pain for many months without a diagnosis being attempted. It is possible that for a long time before their arrival at the Clinic sufficient evidence might have been obtained to make diagnosis possible, and an early operation would have saved them months of agony and a final hopeless prognosis.

Every writer on this subject has deplored the frequency with which these tumors masquerade under a diagnosis of double sciatica, myositis or neuromuscular pain without any attempt being made to exclude the presence of a tumor. Even if there are no signs of tumor a long history of pain in a definite area should be sufficient to warrant the patient being kept under close observation. It is only by the recognition of early signs and their proper valuation

that a large number of patients may be saved from permanent paralysis or death. Further, the differentiation of tumor from other conditions is at times difficult. The intense constant pain is usual. This is sufficient evidence for the rejection of degenerative processes such as spinal bifida occulta, although this was an associated condition in Case 8. Elsberg operated in a case of spina bifida in 1908 and the patient developed a lipoma requiring laminectomy in 1910. Fuchs, in 1909, coined a term, myelodysplasia, to cover all sorts of congenital anomalies of the lower portion of the central nervous system. The most prominent symptoms were enuresis, sensory disturbances, and weakness of the lower limbs. Spiller, in 1916, reviewed this article and made more clear our conception of what may be included under this term. The sensory changes, weaknesses and atrophy of the lower extremities suggest tumor, but a careful search and roentgen-ray examination disclose such anomalies as spina bifida occulta, hypertrichosis over the skin of the sacral area, lipomas of the sacrum and associated stigmas of maldevelopment. Closely linked to this conception, if not included in it, is the abiotrophia of Gowers. It may start in the second or third decade of life and frequently cause strong suspicion of a progressive lesion-like tumor. The absence of pain, the long slow development, perhaps dating from earliest childhood, prevents such a diagnosis.

Hypertrophic arthritis of the lumbar spine with root pressure from bone overgrowth simulates tumor closely. A case of this kind was described by Bailey, in which, following an old injury, the patient developed pain, progressive weakness, and other symptoms suggesting a tumor compressing the lower segments of the cord. Laminectomy revealed granulations on the dura mater and bony overgrowth compressing the cord.

Tuberculous or syphilitic meningoradiculitis has to be excluded and all possibility of syphilis in the patient sought for. Laignel-Lavastine and Verliac described a case of the latter disease involving only half of the caudal roots, constituting an almost exact hemileSION. No similar instance was found in our records.

Toxic neuritis of the cauda equina, first described by Kennedy, Elsberg and Lambert in 1914, is difficult to distinguish from tumor. These authors presented the records of five cases, all progressive in type, and the course of illness in two was as long as two years. Their full description of the disease makes it evident that differentiation from tumor would be very difficult. Reynolds, in 1919, gave a full report of a similar case with a history as long as eight years, and the findings at operation were much the same as in the other five cases, namely, that the caudal roots were swollen, discolored, congested, and matted together.

I found the record of a patient in the Mayo Clinic who had been operated on for caudal tumor with very similar findings. The his-

tory dated back six years. The patient had pain, incontinence, and saddle anesthesia. The disease was progressive. Operative procedure did not reveal tumor but the caudal roots were swollen and congested. The suggestion of tumor was very strong and the diagnosis could hardly have been avoided. The spinal fluid was normal in this case.

Sacral tuberculosis may give rise to symptoms and signs like tumor, but in such cases the roentgen ray should aid in the diagnosis.

**LOCALIZATION OF TUMORS.** Before discussing this phase of the subject it may be well to consider a case that but for a rectal examination would have been diagnosed as caudal tumor.

**CASE 9 (313623).** Mr. J.-J. F., an emaciated anemic man, aged sixty years, came to the Clinic, April 13, 1920, complaining of incontinence of urine, constipation, and pain in the back of his legs. Twelve months before he had noticed severe pain in and around the anus. He became constipated, which rapidly became more and more severe. Nine months before the pain had spread to the posterior aspect of the thigh and four months before his sexual power failed. He became incontinent of urine nine months after the onset, and a little later he lost rectal control. Eleven months after the onset he noticed an anesthesia and analgesia over the buttocks and posteromedial aspect of the thigh. His pain was relieved by walking around; he called it a "sharp rheumatic" pain. He had no knowledge of the passing of urine and could neither start it nor stop it. He had to dig out impacted feces unless they became liquid, then he was unconscious of their passage.

Examination showed a well-marked anesthesia corresponding to the fourth and fifth sacral segments, with some disturbance of sensations in the skin supplied by the third sacral segment (Fig. 6). All other areas were normal. There was no muscular weakness and the Achilles reflexes were only slightly diminished. Anal and bulbocavernous reflexes were absent and the spinal fluid was normal. Bladder and rectal control was absent. By digital examination of the rectum a large, hard, fixed tumor, rounded, with convex surface anteriorly about 8 cm. across, was found adherent to the anterior surface of the sacrum. It protruded into the rectum, but did not seem to arise therefrom. Several roentgenograms of the sacrum revealed nothing of note.

Before the position of the growth in this case was made manifest the signs and symptoms gave the picture of a tumor which might be in any of four separate and distinct positions. (1) An intramedullary tumor confined to the conus medullaris; (2) a tumor arising in the filum terminale, just as it arises from the tip of the conus; (3) a tumor arising from the same structure low in the sacral canal, and (4) a tumor in the pelvis. A tumor in the first position would destroy the third, fourth, and fifth sacral and the coccygeal

segments, a tumor in the second and third positions would press on or involve the roots of the same segments either in the lumbar canal or sacral canal, and finally, a tumor in the pelvis would press on and destroy the same roots after they emerged from the sacral foramina and had formed plexuses, destroying at the same time the ganglia and plexuses of the sympathetic system. The rectal examination demonstrated at once a tumor in the latter position.

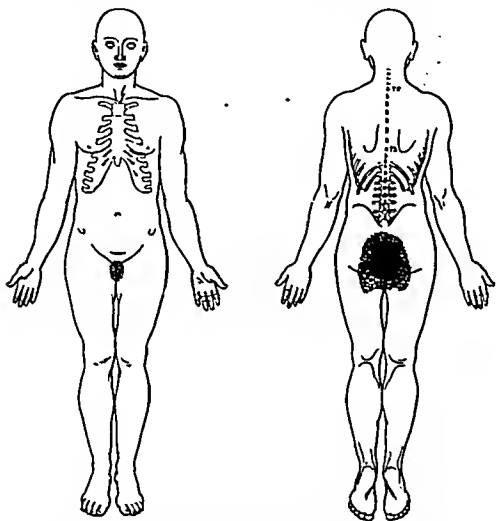


FIG. 6.—Case 9 (313623). Complete incontinence of urine and feces. Intrapelvic tumor involving the sacral nerve roots.

Many writers have endeavored to tabulate the differences between conus and caudal tumors, but a glance at the cases herein described will show the difficulty of being sure whether the tumor is intramedullary or is growing from the caudal roots. A tumor of this region follows no laws and selects its own path. A caudal tumor, as in Case 1, may press on the conus and produce signs of intramedullary damage such as fibrillary twitching. On the other hand a tumor originally intramedullary may spread from there to the roots and, as in Case 6, produce the intense pains associated with root tumors. Jacobsohn, in a paper on this subject, described a case in

which the diagnosis between conus and caudal tumor was impossible and a laminectomy showed the cauda intact. Necropsy showed a sarcoma of the dura compressing the conus on the right side. He insists on the difficulty of diagnosis in similar cases.

In Case 6, because the fourth and fifth lumbar and the first and second sacral segments were damaged, with preservation of the third, fourth, and fifth sacral segments, a diagnosis of intramedullary growth was made, as in a caudal lesion the central fibers could hardly have escaped. They are often the first to be affected.

In the early stages of growth of the tumor the exact localization may be impossible. It is only by careful and close study of each individual case on its own merits, and by applying the results of past experience, that some idea of the position, extent, and nature of the tumor may be ascertained.

**Summary.** 1. Tumors of the cauda equina, conus and epiconus are not rare. Of thirty-three patients with tumors of the spinal cord operated on since 1916, eight had tumors in one of these areas.

2. The course of the disease to the time of operation was relatively long, the longest being eight years and the shortest five months.

3. The signs and symptoms are characterized, on the whole, by pain and weakness of the lower extremities and perianal or saddle anesthesio, with loss of control of the bladder and rectum.

4. The pain may precede the other signs for many months; intermittent at first, it is constant toward the end. Movement usually relieves it and a sitting position is felt by the patient to be the most comfortable.

5. Sphincteric disturbance may be absent, although other signs are well marked.

6. Spinal puncture is a valuable aid, primarily to exclude other diseases; it may also give a hint of the condition of the dural canal.

7. While diagnosis of tumor somewhere in the lower segments of the cord is comparatively simple, its exact localization is often impossible or extremely difficult, and a surprising degree of involvement of structures is often present with few signs and symptoms to correspond.

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## ERYTHROPOIETIC ACTION, CUMULATIVE EFFECT AND ELIMINATION OF GERMANIUM DIOXIDE.

BY JOHN HUGHES MÜLLER, M.A., PH.D.

AND

MIRIAM STEWART ISZARD, M.A.

(From the John Harrison Laboratory of Chemistry and the School of Public Hygieoe,  
University of Pennsylvania, Philadelphia, Pa.)

THE importance of germanium dioxide as an erythropoietic agent has recently been established by the investigations of Hammett, Nowrey and Müller. This experimental work was conducted at the Wistar Institute of Anatomy and Biology, Philadelphia, and the article treating of the results appeared in the *Journal of Experimental Medicine*, February, 1922.

The abstract of this article pointed out that the tests were conducted on albino rats. The results of experimentation showed that "there took place, as the result of the administration of the compound, a marked and statistically valid rise in the number of the erythrocytes. There was no corresponding leukemia. Autopsy of the treated rats showed, on gross inspection, that the bone-marrow and liver probably participate in the reaction which results in the erythropoiesis."<sup>1</sup>

As an outgrowth of the above-mentioned work the authors of this paper have conducted several series of tests, which work was

<sup>1</sup> Hammett, Nowrey and Müller: Erythropoietic Actioo of Germanium Dioxide, *Jour. Exper. Med.*, 1922, 35.